International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2020): 7.803

Comparative Analysis and Simulation of Hexagonal Shape Microstrip Patch Antenna

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Abstract: ***In this review paper, we have designed a Microstrip Patch Antenna in the shape of a hexagon which is intended to operate at afrequency of 2.45 GHz which is the desired frequency in the S-Band applications.. A comparative analysis is done using two substrate materials and both the designs are simulated. The substrate materials used in the designing process are Glass Epoxy (FR4), Bakelite and Rogers /RT-Duroid 5880 respectively. In addition to that, the use of a parasitic element is made. The main objective behind introducing this parasitic element was to achieve a wider bandwidth which will ultimately lead to an improvement in the antenna's overall performance. The eventual results obtained in the form of total antenna gain, total directivity, radiation pattern and S-parameters which are observed and compared.***

Keywords: Hexagonal patch, S-Band, FR4, Bakelite, Rogers/RT-Duroid, Parasitic element

1. Introduction

The Microstrip Patch Antenna is a monolayer arrangement which normally comprises of four parts- ground plane, substrate, patch and the feeding element. A fine metallic strip is located on the ground plane with a di-electric material as an intermediate. A method called photo-etching is performed on the di-electric susbstrate upon which the radiating element and feed lines are

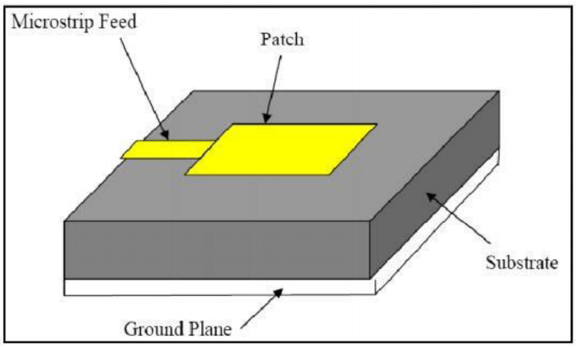

Figure 1: Microstrip Patch Antenna

positioned. Generally, the patch or microstrip is chosen to be rectangular, circular or square in shape for the ease of analysis and fabrication but in practical it can take up any continuous shape as long as it can be attained.

Microstrip Patch Antenna is more capable than other antennas due to its small size, easiness of integration, light weight, and low profile which can be used in the field of radar technology, space science, biomedical research and wireless communication systems. However compared with conventional microwave antennas,MPA's also have some limitations such as low gain, large ohmic loss in the array and radiation of energy mostly to half space.

Over the past years, various means have been put forward to amplify the bandwidth of MPA's, for example expanding the substrate thickness, reducing the substrate dielectric constant, loading chip resistor, making use of parasitic patches in single layer and multilayers configuration. Among the declared methods, introducing a parasitic element is chosen to test how the parasitic patch can help boost the bandwidth of the antenna. As mentioned above, a parasitic element is created while designing the structure which is inturn responsible for amplifying the antenna bandwidth.

2. Antenna Design

a) Hexagonal Patch using FR4 substrate

The schematic layout of a microstrip patch antenna making use of FR4 epoxy substrate material is observed in Fig.2. The dimensions of the antenna patch is given as 10.39 mm x 17.83 mm x 2mm i.e (L x W x H). The relative permittivity of this substrate equals 4.4 and it possesses a loss tangent of 0.002. The feeding mechanism employed here is Microstrip line feeding. Antenna shape is attained by imposing coordinate values to each of its part.

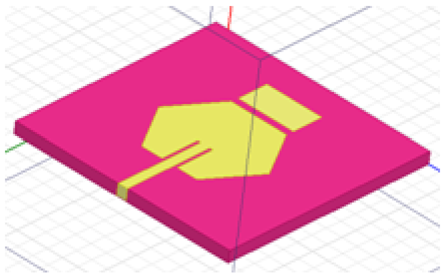

Figure 2: Configuration using FR4 substrate

b) Hexagonal Patch using Bakelite substrate

The same structure is designed again but now using another substrate material called Bakelite and its performance is analyzed. The thickness (height) of the patch is kept constant throughout the designing procedure. As discussed earlier, a parasitic element is added in order to acquire a larger bandwidth which ultimately improves antenna efficiency.It possesses a The polar plots and radiation pattern are taken to be the final outcomes of the simulation. The systematic configuration of Bakelite is shown in Fig.3.

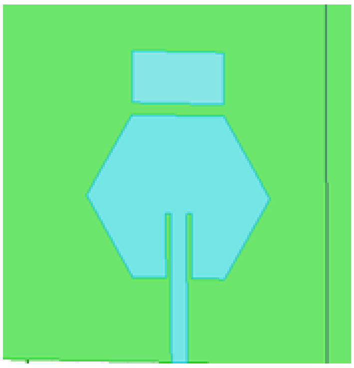

Figure 3: Design using Bakelite substrate

c) Hexagonal Patch using RT-Duroid 5880 substrate

The final formation of the microstrip patch antenna was proposed using Rogers/RT-Duroid 5880 as the substrate material.It bears a dielectric constant of value 2.2 and a loss tangent of 0.02. The antenna resonates over the S-band for a frequency of 2.45 GHz. The antenna has undergone the same feeding mechanism which is the microstrip line feeding technique. Eventual product is observed in terms of gain, directivity, return loss and the radiation graphs. The geometry below Fig.4 indicates the setup of the patch antenna using the above substrate material.

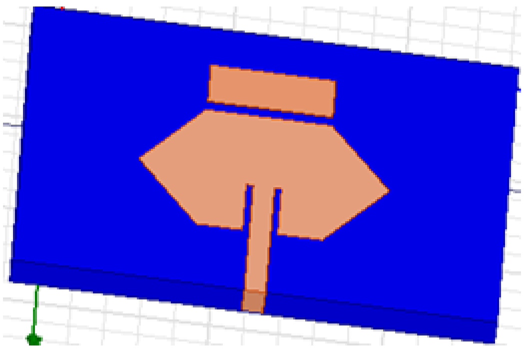

Figure 4: Geometry using Rogers/RT-Duroid 5880 substrate

3. Simulation Results and Analysis

a) Return Loss

Return loss (RL) is the difference in dB between the forward power and the reflected power. Large value of return loss gives less reflected power. Higher the return, more power radiation will occur. Even in the case of a load that reflects 100% of the forward power, some power will be lost along the path from the source to the load and back.

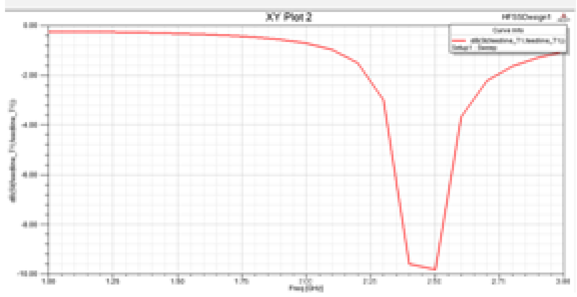

Figure 5: Return loss of antenna using FR4

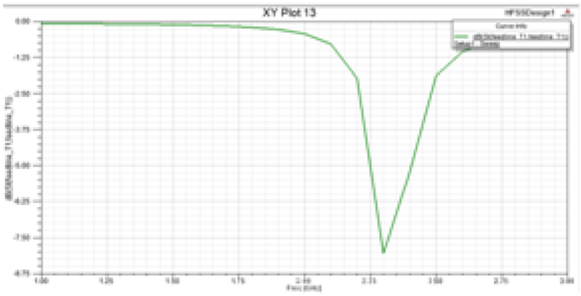

Figure 6: Return loss of antenna using Bakelite

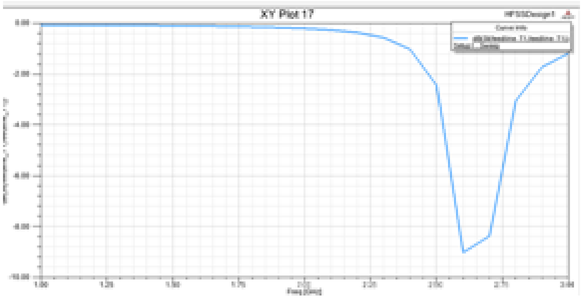

Figure 7: Return loss of the antenna using Rogers/RT-Duroid 5880

b) Directivity

Directivity in other words is also known to be the maximum directive gain of an antenna and it is denoted by D. It is defined as the ratio of maximum radiation intensity of test antenna to average radiation intensity by the test antenna.This quantity basically does not rely on the losses of antenna and hence is considered to be the figure of merit in elaborating the potential of the antenna in concentrating power. When no losses occurring in an antenna it means that gain of the antenna is equal to its directivity.

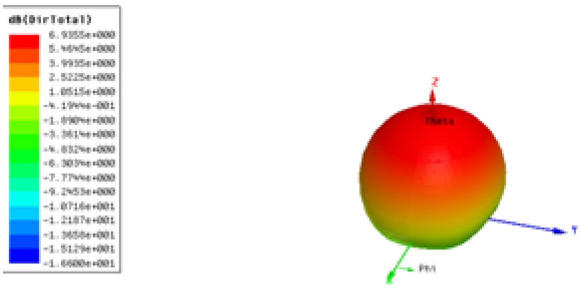

Figure 8: Directivity of antenna using FR4

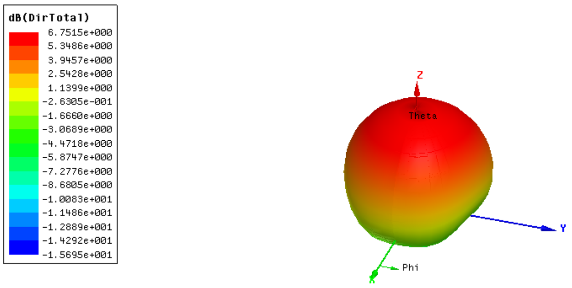

Figure 9: Directivity of antenna using Bakelite

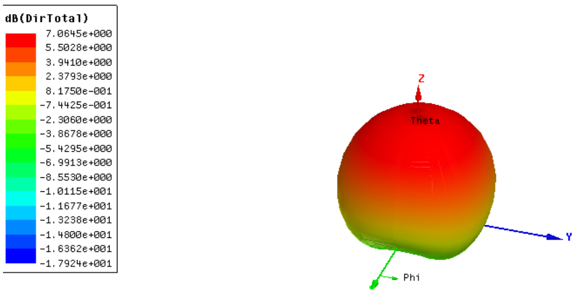

Figure 10: Directivity of antenna using Rogers/RT-Duroid 5880

c) Gain

Antenna gain illustrates how powerful a signal can transmit or receive in a particular direction. During reception of the signal, the gain illustrates how nicely the antenna is able to convert radio waves appearing from a specified direction into electrical power. When no direction is particularized, gain is understood to point out to the highest value of the gain.

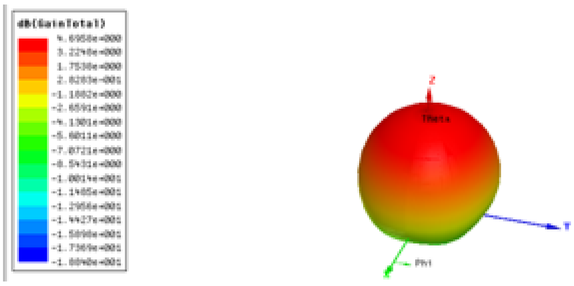

Figure 11: Gain of antenna using FR4

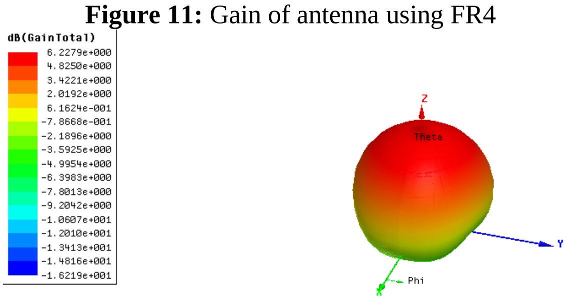

Figure 12: Gain of antenna using Bakelite

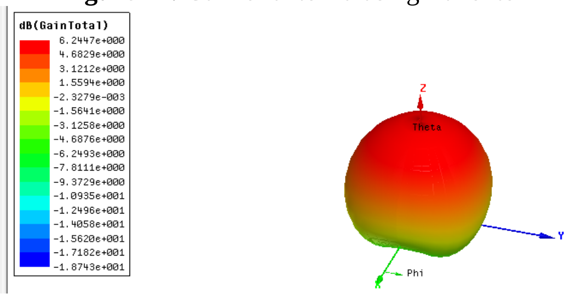

Figure 13: Gain of antenna using Rogers/RT-Duroid 5880

d) Radiation Pattern

Radiation Pattern is mainly used to describe the radiation behavior of an antenna. Hence it can either be a graphical depiction or a mathematical function of the radiation properties like strength, directivity etc. Since radiation is extreme in the far field region, it is directed only in terms of far fields.

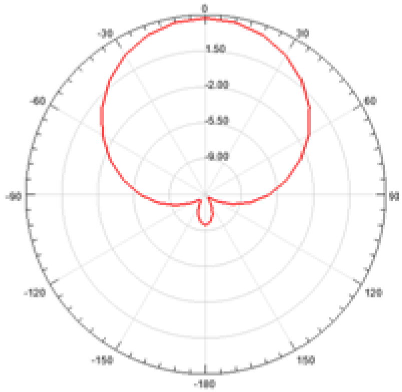

Figure 14: Radiation Pattern obtained using FR4

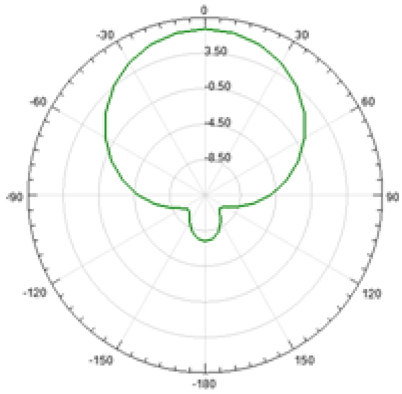

Figure 15: Radiation Pattern obtained using Bakelite

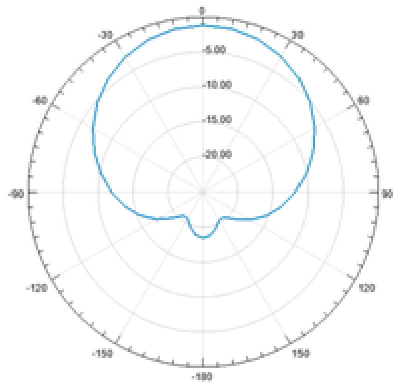

Figure 16: Radiation Pattern obtained using Rogers/RT-Duroid 5880

4. Comparative Evaluation

Table I: Comparison of Microstrip Patch Antenna using various substrate

Substrate	Return Loss (dB)	Directivity (dB)	Gain (dB)
FR4	-9.7	6.9	4.69
Bakelite	-8.02	6.75	6.22
Rogers/RT-Duroid	-11.8	7.06	6.44

5. Conclusion

A basic microstrip patch antenna is designed in the shape of a regular hexagon at an operation frequency of 2.45GHz on three distinct substrate materials namely FR4, Bakelite and Rogers/RT-Duroid5880. On completion of the design, it was observed that it possessed a narrow bandwidth along with average performance characteristics. To resolve this issue, a parasitic element was introduced in the design which made a significant change in the bandwidth.The final parameters were obtained without hampering the thickness of the substrate which is the height of the substrate in other words taken to be 2 mm. All the plots, simulations and estimations are obtained using HFSS software.

Out of the three substrates, it was visibly noticed that Rogers/RT-Duroid substrate showed the best performance in terms of all the antenna parameters calculated. It possessed a return loss of -11.8dB at a resonationg frequency of 2.4GHz. The directivity and gain were found out to be 7.06 dB and 6.44 dB respectively. The next substrate which gave better performance characteristics was Glass Epoxy FR4 substrate having a return loss of -9.7 dB. The directivity and gain obtained were 6.9 dB and 4.69 dB respectively. For Bakelite substrate the return loss was seen to be -8.02 dB followed by 6.75 dB and 6.22 dB directivity and gain respectively.

It can further be concluded that an antenna can be designed in any shape as long it is in a continuous form. One can also make use of Coaxial Probe Feeding Mechanism in order to achieve more wider bandwidth and better impedence matching.

6. Acknowledgement

I would like to express my sincere gratitude to the Principal, Dr. R. B. Lohani and the Head of Department (ETC), Dr. H.G. Virani of Goa College of Engineering for permitting me to carry out the research work. Lastly, would like to thank Prof. Sangam Borkar sir for his valuable inputs, guidance and continuous encouragement throughout the project.

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